CHAPTER 3 (Odd)

1. a. 0.5 in. = **500 mils** b. 0.01 in. = **10 mils**

   c. 0.004 in. = **4 mils** d. 1 in. = **1000 mils**

   e. $0.02\,\cancel{\text{ft}}\left[\dfrac{12\ \cancel{\text{in.}}}{1\ \cancel{\text{ft}}}\right]\left[\dfrac{10^3\ \text{mils}}{1\ \cancel{\text{in.}}}\right] = \mathbf{240\ mils}$

   f. $0.01\ \cancel{\text{cm}}\left[\dfrac{1\ \text{in.}}{2.54\ \cancel{\text{cm}}}\right] = 0.003937\ \text{in.} = \mathbf{3.937\ mils}$

3. $A_{CM} = (d_{mils})^2 \Rightarrow d_{mils} = \sqrt{A_{CM}}$

   a. $d = \sqrt{1600\ \text{CM}} = 40\ \text{mils} = \mathbf{0.04\ in.}$ b. $d = \sqrt{900\ \text{CM}} = 30\ \text{mils} = \mathbf{0.03\ in.}$

   c. $d = \sqrt{40{,}000\ \text{CM}} = 200\ \text{mils} = \mathbf{0.2\ in.}$ d. $d = \sqrt{625\ \text{CM}} = 25\ \text{mils} = \mathbf{0.025\ in.}$

   e. $d = \sqrt{7.75\ \text{CM}} = 2.78\ \text{mils} = \mathbf{0.00278\ in.}$ f. $d = \sqrt{81\ \text{CM}} = 9\ \text{mils} = \mathbf{0.009\ in.}$

5. $R = \rho\dfrac{l}{A}$, $\rho = 9.9$, 50 yd = 150 ft

   0.0045 in. = 4.5 mils, $A_{CM} = (4.5\ \text{mils})^2 = 20.25\ \text{CM}$

   $R = \rho\dfrac{l}{A} = \dfrac{(9.9)(150\ \text{ft})}{(20.25\ \text{CM})} = \mathbf{73.33\ \Omega}$

7. $\dfrac{1}{32}" = 0.03125" = 31.25\ \text{mils}$, $A_{CM} = (31.25\ \text{mils})^2 = 976.56\ \text{CM}$

   $R = \rho\dfrac{l}{A} \Rightarrow l = \dfrac{RA}{\rho} = \dfrac{(2.2\ \Omega)(976.56\ \text{CM})}{600} = \mathbf{3.581\ ft}$

9. a. $R_{silver} > R_{copper} > R_{aluminum}$

   b. Silver: $R = \rho\dfrac{l}{A} = \dfrac{(9.9)(1\ \text{ft})}{1\ \text{CM}} = \mathbf{9.9\ \Omega}$ $\{ A_{CM} = (1\ \text{mil})^2 = 1\ \text{CM}$

   Copper: $R = \rho\dfrac{l}{A} = \dfrac{(10.37)(10\ \text{ft})}{100\ \text{CM}} = \mathbf{1.037\ \Omega}$ $\{ A_{CM} = (10\ \text{mils})^2 = 100\ \text{CM}$

   Aluminum: $R = \rho\dfrac{l}{A} = \dfrac{(17)(50\ \text{ft})}{2500\ \text{CM}} = \mathbf{0.34\ \Omega}$ $\{ A_{CM} = (50\ \text{mils})^2 = 2500\ \text{CM}$

11. a. 3" = 3000 mils, 1/2" = 0.5 in. = 500 mils

   Area = $(3 \times 10^3\ \text{mils})(5 \times 10^2\ \text{mils} = 15 \times 10^5\ \text{sq. mils}$

   $15 \times 10^5\ \text{sq}\ \cancel{\text{mils}}\left[\dfrac{4/\pi\ \text{CM}}{1\ \text{sq}\ \cancel{\text{mil}}}\right] = 19.108 \times 10^5\ \text{CM}$

   $R = \rho\dfrac{l}{A} = \dfrac{(10.37)(4')}{19.108 \times 10^5\ \text{CM}} = \mathbf{21.71\ \mu\Omega}$

b. $R = \rho\frac{l}{A} = \frac{(17)(4')}{19.108 \times 10^5 \text{ CM}} = \mathbf{35.59\ \mu\Omega}$

c. increases

d. decreases

13. $A = \frac{\pi d^2}{4} \Rightarrow d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(0.04 \text{ in.}^2)}{\pi}} = 0.2257 \text{ in.}$

$d_{\text{mils}} = 225.7 \text{ mils}$
$A_{\text{CM}} = (225.7 \text{ mils})^2 = 50{,}940.49 \text{ CM}$

$$\frac{R_1}{R_2} = \frac{\rho_1\frac{l_1}{A_1}}{\rho_2\frac{l_2}{A_2}} = \frac{\cancel{\rho_1}l_1A_2}{\cancel{\rho_2}l_2A_1} = \frac{l_1A_2}{l_2A_1} \qquad (\rho_1 = \rho_2)$$

and $R_2 = \frac{R_1l_2A_1}{l_1A_2} = \frac{(800 \text{ m}\Omega)(300 \text{ ft})(40{,}000 \text{ CM})}{(200 \text{ ft})(50{,}940.49 \text{ CM})} = \mathbf{942.28\ m\Omega}$

15. a. #8: $R = 1800\cancel{\text{ft}}\left[\frac{0.6282\ \Omega}{1000\ \cancel{\text{ft}}}\right] = \mathbf{1.1308\ \Omega}$

#18: $R = 1800\cancel{\text{ft}}\left[\frac{6.385\ \Omega}{1000\ \cancel{\text{ft}}}\right] = \mathbf{11.493\ \Omega}$

b. #18:#8 = 11.493 Ω:1.1308 Ω = 10.164:1 ≅ **10:1**

c. #18:#8 = 1624.3 CM:16,509 CM = 1:10.164 ≅ **1:10**

17. a. A/CM = 230 A/211,600 CM = **1.087 mA/CM**

b. $\frac{1.087 \text{ mA}}{\cancel{\text{CM}}}\left[\frac{1\ \cancel{\text{CM}}}{\frac{\pi}{4}\ \cancel{\text{sq mils}}}\right]\left[\frac{1000\ \cancel{\text{mils}}}{1 \text{ in.}}\right]\left[\frac{1000\ \cancel{\text{mils}}}{1 \text{ in.}}\right] = \mathbf{1.384\ kA/in.^2}$

c. $5\ \cancel{\text{kA}}\left[\frac{1 \text{ in.}^2}{1.348\ \cancel{\text{kA}}}\right] = \mathbf{3.6127\ in.^2}$

19. a. $\frac{1}{2}''\left[\frac{2.54 \text{ cm}}{1''}\right] = 1.27 \text{ cm}, \quad 3\ \cancel{\text{in.}}\left[\frac{2.54 \text{ cm}}{1\ \cancel{\text{in.}}}\right] = 7.62 \text{ cm}$

$4\ \cancel{\text{ft}}\left[\frac{12\ \cancel{\text{in.}}}{1\ \cancel{\text{ft}}}\right]\left[\frac{2.54 \text{ cm}}{1\ \cancel{\text{in.}}}\right] = 121.92 \text{ cm}$

$R = \rho\frac{l}{A}\ \frac{(1.724 \times 10^{-6})(121.92 \text{ cm})}{(1.27 \text{ cm})(7.62 \text{ cm})} = \mathbf{21.71\ \mu\Omega}$

b. $R = \rho\frac{l}{A} = \frac{(2.825 \times 10^{-6})(121.92 \text{ cm})}{(1.27 \text{ cm})(7.62 \text{ cm})} = \mathbf{35.59\ \mu\Omega}$

c. increases

d. decreases

21. $R = R_s\dfrac{l}{w} \Rightarrow w = \dfrac{R_s l}{R} = \dfrac{(150\ \Omega)(1/2\text{ in.})}{500\ \Omega} = \mathbf{0.15\ in.}$

23. $\dfrac{234.5 + t_1}{R_1} = \dfrac{234.5 + t_2}{R_2} \Rightarrow \dfrac{234.5 + 10}{2\ \Omega} = \dfrac{234.5 + 60}{R_2}$

$R_2 = \dfrac{(294.5)(2\ \Omega)}{244.5} = \mathbf{2.409\ \Omega}$

25. $C = \dfrac{5}{9}(°F - 32) = \dfrac{5}{9}(32 - 32) = 0°\ (=32°F)$

$C = \dfrac{5}{9}(70 - 32) = 21.11°\ (=70°F)$

$\dfrac{234.5° + 21.11°}{4\ \Omega} = \dfrac{234.5° + 0°}{R_2}$

$R_2 = \dfrac{(234.5)(4\ \Omega)}{255.61} = \mathbf{3.67\ \Omega}$

27. $\dfrac{243 + (-30)}{0.04\ \Omega} = \dfrac{243 + 0}{R_2}$

$R_2 = \dfrac{(243)(40\ m\Omega)}{213} = \mathbf{46\ m\Omega}$

29. a. $\dfrac{238.5}{0.92\ \Omega} = \dfrac{234.5 + t_2}{1.06\ \Omega}$

$274.793 = 234.5 + t_2$

$t_2 = \mathbf{40.29°C}$

b. $\dfrac{238.5}{0.92\ \Omega} = \dfrac{234.5 + t_2}{0.15\ \Omega}$

$38.886 = 234.5 + t_2$

$t_2 = \mathbf{-195.61°C}$

31. a. $\alpha_{20} = \dfrac{1}{|T| + 20°C} = \dfrac{1}{234.5 + 20} = \dfrac{1}{254.5} = 0.003929 \cong \mathbf{0.00393}$

b. $R = R_{20}[1 + \alpha_{20}(t - 20°C)]$

$1\ \Omega = 0.8\ \Omega[1 + 0.00393(t - 20°)]$

$1.25 = 1 + 0.00393t - 0.0786$

$1.25 - 0.9214 = 0.00393t$

$0.3286 = 0.00393t$

$t = \dfrac{0.3286}{0.00393} = \mathbf{83.61°C}$

33. Table: 1000′ of #12 copper wire = 1.588Ω @ 20°C

$C° = \dfrac{5}{9}(F° - 32) = \dfrac{5}{9}(115 - 32) = 46.11°C$

$R = R_{20}[1 + \alpha_{20}(t - 20°C)]$

$= 1.588\Omega[1 + 0.00393(46.11 - 20)]$

$= \mathbf{1.751\ \Omega}$

35. Fig. 3.21: At 90°C, +1% = 0.01(10,000) = 100 Ω, ∴ 10,100 Ω at 90°C

$\Delta R = R_2 - R_1 = 10{,}100\ \Omega - 10{,}000 = 100\ \Omega$

$\Delta T = 90° - 20°\text{C} = 70°\text{C}$

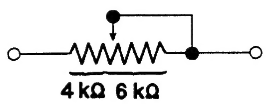
$$\text{PPM} = \frac{(\Delta R)(10^6)}{(R_{\text{nominal}})(\Delta T)} = \frac{(100\ \Omega)(10^6)}{(10\ \text{k}\Omega)(70)} = \mathbf{142.86}$$

41. $-30°\text{C} \Rightarrow +2\% = 200\ \Omega \Rightarrow$ **10.2 kΩ**

$100°\text{C} \Rightarrow 1.5\% = 150\ \Omega \Rightarrow$ **10.15 kΩ**

43. **6.5 kΩ**

45.



47. a. 220 Ω = Red, Red, Brown, Silver

b. 4700 Ω = Yellow, Violet, Red, Silver

c. 68 kΩ = Blue, Gray, Orange, Silver

d. 9.1 MΩ = White, Brown, Green, Silver

49. $\left.\begin{array}{l} 10\ \Omega \pm 10\% = 10\ \Omega \pm 1\ \Omega = 9\ \Omega - 11\ \Omega \\ 15\ \Omega \pm 10\% = 15\ \Omega \pm 1.5\ \Omega = 13.5\ \Omega - 16.5\ \Omega \end{array}\right\}$ No

51. a. Table 3.2, Ω/1000′ = 6.385 Ω

$$G = \frac{1}{R} = \frac{1}{6.385\ \Omega} = \mathbf{156.6\ mS}$$

$$\text{or } G = \frac{A}{\rho l} = \frac{1{,}624.3\ \text{CM (Table 3.2)}}{(10.37)(1000')} = \mathbf{156.6\ mS}$$

b. $G = \dfrac{1{,}624.3\ \text{CM}}{(17)(1000')} = \mathbf{95.54\ mS}$ (Al)

c. $G = \dfrac{1.624.3\ \text{CM}}{(74)(1000')} = \mathbf{21.95\ mS}$ (Fe)

53. Good: $R < 1\ \Omega$ (low)

Bad: $R = \infty\ \Omega$

55. Good: Some resistance (filament not open)

Bad: $R = \infty\ \Omega$ (filament open)

57. a. Log scale: 10 fc ⇒ 3 kΩ

100 fc ⇒ 0.4 kΩ

b. negative

c. no—log scales imply linearity

d. 1 kΩ ⇒ ≅30 fc

10 kΩ ⇒ ≅2 fc

$$\left|\frac{\Delta R}{\Delta fc}\right| = \frac{10\ \text{k}\Omega - 1\ \text{k}\Omega}{30\ \text{fc} - 2\ \text{fc}} = 321.43\ \Omega/\text{fc}$$

$$\text{and } \frac{\Delta R}{\Delta \text{fc}} = -321.43\ \Omega/\text{fc}$$

CHAPTER 3 (Even)

2. a. $0.050 \text{ in.} = 50 \text{ mils}, A_{CM} = (50 \text{ mils})^2 = \mathbf{2500\ CM}$

   b. $0.016 \text{ in.} = 16 \text{ mils}, A_{CM} = (16 \text{ mils})^2 = \mathbf{256\ CM}$

   c. $0.30 \text{ in.} = 300 \text{ mils}, A_{CM} = (300 \text{ mils})^2 = \mathbf{90 \times 10^3\ CM}$

   d. $$[0.1\ \cancel{\text{cm}}]\left[\frac{1 \text{ in.}}{2.54\ \cancel{\text{cm}}}\right] = 0.0394 \text{ in.} = 39.4 \text{ mils}$$
   $$A_{CM} = (39.4 \text{ mils})^2 = \mathbf{1552.36\ CM}$$

   e. $$0.003\ \cancel{\text{ft}}\left[\frac{12 \text{ in.}}{1\ \cancel{\text{ft}}}\right] = 0.036 \text{ in.} = 36 \text{ mils}$$
   $$A_{CM} = (36 \text{ mils})^2 = \mathbf{1296\ CM}$$

   f. $$0.0042\ \cancel{\text{m}}\left[\frac{39.37 \text{ in.}}{1\ \cancel{\text{m}}}\right] = 0.1654 \text{ in.} = 165.4 \text{ mils}$$
   $$A_{CM} = (165.4 \text{ mils})^2 = \mathbf{27{,}357.16\ CM}$$

4. $0.01 \text{ in.} = 10 \text{ mils}, A_{CM} = (10 \text{ mils})^2 = 100 \text{ CM}$
   $$R = \rho\frac{l}{A} = (10.37)\frac{(200')}{100 \text{ CM}} = \mathbf{20.74\ \Omega}$$

6. a. $$A = \rho\frac{l}{R} = \frac{(17)(80')}{2.5\ \Omega} = \mathbf{544\ CM}$$

   b. $$d = \sqrt{A_{CM}} = \sqrt{544 \text{ CM}} = 23.32 \text{ mils} = \mathbf{0.0233\ in.}$$

8. a. $$A_{CM} = \rho\frac{l}{R} = \frac{(10.37)(300')}{2.5\ \Omega} = \mathbf{1244.40\ CM}$$ b. larger c. smaller

10. $$\rho = \frac{RA}{l} = \frac{(500\ \Omega)(94 \text{ CM})}{1000'} = 47 \Rightarrow \textbf{nickel}$$

12. $l_2 = 2l_1, A_2 = A_1/4, \rho_2 = \rho_1$
   $$\frac{R_2}{R_1} = \frac{\dfrac{\rho_2 l_2}{A_2}}{\dfrac{\rho_1 l_1}{A_1}} = \frac{\cancel{\rho_2} l_2 A_1}{\cancel{\rho_1} l_1 A_2} = \frac{2l_1 A_1}{l_1 A_1/4} = 8$$
   and $R_2 = 8R_1 = 8(0.2\ \Omega) = 1.6\ \Omega$
   $\Delta R = 1.6\ \Omega - 0.2\ \Omega = \mathbf{1.4\ \Omega}$

14. a. #11: $$450\ \cancel{\text{ft}}\left[\frac{1.260\ \Omega}{1000\ \cancel{\text{ft}}}\right] = \mathbf{0.567\ \Omega}$$

   #14: $$450\ \cancel{\text{ft}}\left[\frac{2.525\ \Omega}{1000\ \cancel{\text{ft}}}\right] = \mathbf{1.136\ \Omega}$$

b. Resistance: #14:#11 = 1.136 Ω:0.567 Ω ≅ **2:1**

c. Area: #14:#11 = 4106.8 CM:8234.0 CM ≅ **1:2**

16. a. $A = \rho\dfrac{l}{R} = \dfrac{(10.37)(30')}{6\ \text{m}\Omega} = \dfrac{311.1\ \text{CM}}{6 \times 10^{-3}} = 51{,}850\ \text{CM} \Rightarrow \#3$

but 110 A ⇒ **#2**

b. $A = \rho\dfrac{l}{R} = \dfrac{(10.37)(30')}{3\ \text{m}\Omega} = \dfrac{311.1\ \text{CM}}{3 \times 10^{-3}} = 103{,}700\ \text{CM} \Rightarrow \mathbf{\#0}$

18. $\dfrac{1}{10}\ \text{in.} = 0.1\ \text{in.}\left[\dfrac{2.54\ \text{cm}}{1\ \text{in.}}\right] = 0.254\ \text{cm}$

$$A = \frac{\pi d^2}{4} = \frac{(3.14)(0.254\ \text{cm})^2}{4} = 0.0506\ \text{cm}^2$$

$$l = \frac{RA}{\rho} = \frac{(2\ \Omega)(0.0506\ \text{cm}^2)}{1.724 \times 10^{-6}} = 58{,}700\ \text{cm} = \mathbf{58.7\ m}$$

20. $R_s = \dfrac{\rho}{d} = 100 \Rightarrow d = \dfrac{\rho}{100} = \dfrac{250 \times 10^{-6}}{100} = \mathbf{2.5\ \mu cm}$

22. a. $d = 1\ \text{in.} = 1000\ \text{mils}$

$A_{CM} = (10^3\ \text{mils})^2 = 10^6\ \text{CM}$

$$\rho_1 = \frac{RA}{l} = \frac{(1\ \text{m}\Omega)(10^6\ \text{CM})}{10^3\ \text{ft}} = \mathbf{1\ CM\text{-}\Omega/ft}$$

b. $1\ \text{in.} = 2.54\ \text{cm}$

$$A = \frac{\pi d^2}{4} = \frac{\pi(2.54\ \text{cm})^2}{4} = 5.067\ \text{cm}^2$$

$$l = 1000\ \text{ft}\left[\frac{12\ \text{in.}}{1\ \text{ft}}\right]\left[\frac{2.54\ \text{cm}}{1\ \text{in.}}\right] = 30{,}480\ \text{cm}$$

$$\rho_2 = \frac{RA}{l} = \frac{(1\ \text{m}\Omega)(5.067\ \text{cm}^2)}{30{,}480\ \text{cm}} = \mathbf{1.662 \times 10^{-7}\ \Omega\text{-cm}}$$

c. $k = \dfrac{\rho_2}{\rho_1} = \dfrac{1.662 \times 10^{-7}\ \Omega\text{-cm}}{1\ \text{CM-}\Omega/\text{ft}} = \mathbf{1.662 \times 10^{-7}}$

24. $\dfrac{236 + 0}{0.02\ \Omega} = \dfrac{236 + 100}{R_2}$

$$R_2 = \frac{(0.02\ \Omega)(336)}{236} = \mathbf{0.028\ \Omega}$$

26. $\dfrac{234.5 + 30}{0.76\ \Omega} = \dfrac{234.5 - 40}{R_2}$

$$R_2 = \frac{(194.5)(0.76\ \Omega)}{264.5} = \mathbf{0.5589\ \Omega}$$

28. a. $68°F = 20°C,\ 32°F = 0°C$

$$\frac{234.5 + 20}{0.002} = \frac{234.5 + 0}{R_2}$$

$$R_2 = \frac{(234.5)(2\ m\Omega)}{254.5} = \mathbf{1.842\ m\Omega}$$

$212°F = 100\ °C$

$$\frac{234.5 + 20}{2\ m\Omega} = \frac{234.5 + 100}{R_2}$$

$$R_2 = \frac{(334.5)(2\ m\Omega)}{254.5} = \mathbf{2.628\ m\Omega}$$

b. $$\frac{\Delta R}{\Delta T} = \frac{2.628\ m\Omega - 2\ m\Omega}{100°C - 20°C} = \frac{0.628\ m\Omega}{80°C} = 7.85\ \mu\Omega/°C \text{ or } \mathbf{7.85 \times 10^{-5}\ \Omega/10°C}$$

30. a. $K = 273.15 + °C$

$50 = 273.15 + °C$

$°C = -223.15°$

$$\frac{234.5 + 20}{10\ \Omega} = \frac{234.5 - 223.15}{R_2}$$

$$R_2 = \frac{11.35}{254.5}(10\ \Omega) = \mathbf{0.446\ \Omega}$$

b. $K = 273.15 + °C$

$38.65 = 273.15 + °C$

$°C = -234.5°$

$$\frac{234.5 + 20}{10\ \Omega} = \frac{234.5 - 234.5}{R_2}$$

$$R_2 = \frac{(0)10\ \Omega}{254.5} = \mathbf{0\ \Omega}$$

Recall -234.5 = **Inferred**
Absolute zero ($R = 0\ \Omega$)

c. $$F = \frac{9}{5}°C + 32 = \frac{9}{5}(-273.15°) + 32 = \mathbf{-459.67°}$$

32. $R = R_{20}[1 + \alpha_{20}(t - 20°C)]$
$= 0.4\ \Omega[1 + 0.00393(16 - 20)] = 0.4\ \Omega[1 - 0.01572] = \mathbf{0.394\ \Omega}$

34. $$\Delta R = \frac{R_{\text{nominal}}}{10^6}(\text{PPM})(\Delta T) = \frac{(22\ \Omega)}{10^6}(200)(65° - 25°) = 0.176\ \Omega$$

$R = R_{\text{nominal}} + \Delta R = \mathbf{22.176\ \Omega}$

38. #12: Area = 6529 CM

$$d = \sqrt{6529\ \text{CM}} = 80.8\ \text{mils} = 0.0808\ \text{in.}\left[\frac{2.54\ \text{cm}}{1\ \text{in.}}\right] = 0.205\ \text{cm}$$

$$A = \frac{\pi d^2}{4} = \frac{\pi(0.205\ \text{cm})^2}{4} = 0.033\ \text{cm}^2$$

$$I = \frac{1\ \text{MA}}{\cancel{\text{cm}^2}}[0.033\ \cancel{\text{cm}^2}] = \mathbf{33\ kA} \gg 20\ \text{A}$$

40. a. 2 times larger b. 4 times larger

42. $120°F \Rightarrow C = \frac{5}{9}(°F - 32) = \frac{5}{9}(120 - 32) = \frac{5}{9}(88) = 48.89°$

Fig. 3.21 – no apparent change from 20° level

$\therefore$ **10 kΩ**

44. **6.25 kΩ and 18.75 kΩ**

46. a. $56{,}000 \pm 5\% = 56{,}000\ \Omega \pm 2800\ \Omega = \mathbf{53{,}200\ \Omega - 58{,}800\ \Omega}$

b. $220\ \Omega \pm 10\% = 220\ \Omega \pm 22\ \Omega = \mathbf{198\ \Omega - 242\ \Omega}$

c. $10\ \Omega \pm 20\% = 10\ \Omega \pm 2\ \Omega = \mathbf{8\ \Omega - 12\ \Omega}$

48. $\left.\begin{array}{l} 10\ \Omega \pm 20\% \Rightarrow 8\ \Omega \rightarrow 12\ \Omega \\ 15\ \Omega \pm 20\% \Rightarrow 12\ \Omega \rightarrow 18\ \Omega \end{array}\right\}$ Yes

50. a. $G = \dfrac{1}{0.086\ \Omega} = \mathbf{11.628\ S}$ b. $G = \dfrac{1}{4000\ \Omega} = \mathbf{0.25\ mS}$

c. $G = \dfrac{1}{2.2 \times 10^6\ \Omega} = \mathbf{0.4545\ \mu S}$

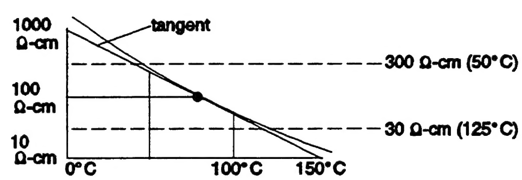
$G_a > G_b > G_c$ vs $R_c > R_b > R_a$

52. $A_2 = 1\frac{2}{3} A_1 = \frac{5}{3} A_1,\ l_2 = \left[1 - \frac{2}{3}\right] l_1 = \frac{l_1}{3},\ \rho_2 = \rho_1$

$$\frac{G_1}{G_2} = \frac{\rho_1 \frac{A_1}{l_1}}{\rho_2 \frac{A_2}{l_2}} = \frac{\cancel{\rho_2} l_2 A_1}{\cancel{\rho_1} l_1 A_2} = \frac{\left[\frac{l_1}{3}\right] A_1}{l_1 \left[\frac{5}{3} A_1\right]} = \frac{1}{5}$$

$G_2 = 5G_1 = 5(100\ \mathrm{S}) = \mathbf{500\ S}$

56. a. $-50°\mathrm{C}$ specific resistance $\cong 10^5\ \Omega$-cm
$50°\mathrm{C}$ specific resistance $\cong 500\ \Omega$-cm
$200°\mathrm{C}$ specific resistance $\cong 7\ \Omega$-cm



b. negative

c. No

d. $\rho = \dfrac{\Delta\ \Omega\text{-cm}}{\Delta T} = \dfrac{300 - 30}{125 - 50} = \dfrac{270\ \Omega\text{-cm}}{75°\mathrm{C}} \cong \mathbf{3.6\ \Omega\text{-cm}/°C}$

58. @ 0.5 mA, V $\cong$ **195 V**
@ 1 mA, V $\cong$ **200 V**
@ 5 mA, V $\cong$ **215 V**
$\Delta V_{total} = 215\ \mathrm{V} - 195\ \mathrm{V} = 20\ \mathrm{V}$
5 mA:0.5 mA = 10:1
compared to
215 V:200 V = 1.075:1